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Home > Auto > Auto Parts & Systems > Brakes > Brake Types

How Anti-Lock Brakes Work

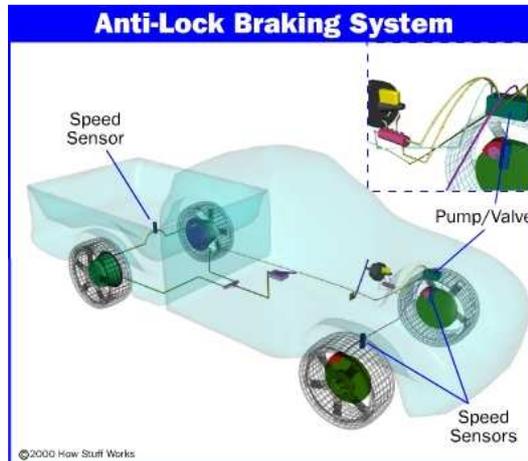
by Karim Nice

Browse the article [How Anti-Lock Brakes Work](#)

Introduction to How Anti-Lock Brakes Work

Stopping a car in a hurry on a slippery road can be very challenging. Anti-lock braking systems (ABS) take a lot of the challenge out of this sometimes nerve-wracking event. In fact, on slippery surfaces, even professional drivers can't stop as quickly without ABS as an average driver can with ABS.

[Brake Image Gallery](#)



Location of anti-lock brake components. See more [brake images](#).

In this article, the last in a six-part series on brakes, we'll learn all about anti-lock braking systems -- why you need them, what's in them, how they work, some of the common types and some associated problems.

The Brakes!

- [How Brakes Work](#)
- [How Master Cylinders and Combination Valves Work](#)
- [How Drum Brakes Work](#)
- [How Disc Brakes Work](#)
- [How Power Brakes Work](#)

The ABS System

The theory behind anti-lock brakes is simple. A **skidding wheel** (where the tire contact patch is sliding relative to the road) has less **traction** than a non-skidding wheel. If you have been stuck on ice, you know that if your wheels are spinning you have no traction. This is because the contact patch is sliding relative to the ice (see [Brakes: How Friction Works](#) for more). By keeping the wheels from skidding while you slow down, anti-lock brakes benefit you in two ways: You'll stop faster, and you'll be able to [steer](#) while you stop.

There are four main components to an ABS system:

- **Speed sensors**
- **Pump**
- **Valves**
- **Controller**



Anti-lock brake pump and valves

Speed Sensors

The anti-lock braking system needs some way of knowing when a wheel is about to lock up. The speed sensors, which are located at each wheel, or in some cases in the [differential](#), provide this information.

Valves

There is a valve in the brake line of each [brake](#) controlled by the ABS. On some systems, the valve has three positions:

- In position one, the valve is **open**; pressure from the [master cylinder](#) is passed right through to the brake.
- In position two, the valve **blocks** the line, isolating that brake from the master cylinder. This prevents the pressure from rising further should the driver push the brake pedal harder.
- In position three, the valve **releases** some of the pressure from the brake.

Pump

Since the valve is able to release pressure from the brakes, there has to be some way to put that pressure back. That is what the pump does; when a valve reduces the pressure in a line, the pump is there to get the pressure back up.

Controller

The controller is a computer in the car. It watches the speed sensors and controls the valves.

ABS at Work

There are many different variations and control algorithms for ABS systems. We will discuss how one of the simpler systems works.

The controller monitors the speed sensors at all times. It is looking for **decelerations** in the wheel that are out of the ordinary. Right before a wheel locks up, it will experience a rapid deceleration. If left unchecked, the wheel would stop much more quickly than any car could. It might take a car five seconds to stop from 60 mph (96.6 kph) under ideal conditions, but a wheel that locks up could stop spinning in less than a second.

The ABS controller knows that such a rapid deceleration is impossible, so it reduces the **pressure** to that brake until it sees an acceleration, then it increases the pressure until it sees the deceleration again. It can do this very quickly, before the [tire](#) can actually significantly change speed. The result is that the tire slows down at the same rate as the car, with the brakes keeping the tires very near the point at which they will start to lock up. This gives the system maximum braking power.

When the ABS system is in operation you will feel a **pulsing** in the brake pedal; this comes from the rapid opening and closing of the valves. Some ABS systems can cycle up to 15 times per second.

Anti-Lock Brake Types

Anti-lock braking systems use different schemes depending on the type of brakes in use. We will refer to them by the number of channels -- that is, how many valves that are individually controlled -- and the number of speed sensors.

Four-channel, four-sensor ABS

This is the best scheme. There is a speed sensor on all four wheels and a separate valve for all four wheels. With this setup, the controller monitors each wheel individually to make sure it is achieving maximum braking force.

Three-channel, three-sensor ABS

This scheme, commonly found on pickup trucks with four-wheel ABS, has a speed sensor and a valve for each of the front wheels, with one valve and one sensor for both rear wheels. The speed sensor for the rear wheels is located in the rear axle.

This system provides individual control of the front wheels, so they can both achieve maximum braking force. The rear wheels, however, are monitored together; they both have to start to lock up before the ABS will activate on the rear. With this system, it is possible that one of the rear wheels will lock during a stop, reducing brake effectiveness.

One-channel, one-sensor ABS

This system is commonly found on pickup trucks with rear-wheel ABS. It has one valve, which controls both rear wheels, and one speed sensor, located in the rear axle.

This system operates the same as the rear end of a three-channel system. The rear wheels are monitored together and they both have to start to lock up before the ABS kicks in. In this system it is also possible that one of the rear wheels will lock, reducing brake effectiveness.

This system is easy to identify. Usually there will be one brake line going through a T-fitting to both rear wheels. You can locate the speed sensor by looking for an electrical connection near the differential on the rear-axle housing.

ABS Questions

- **Should I pump the brake pedal when stopping in slippery conditions?**

You absolutely should not pump the brake pedal in a car with ABS. Pumping the brakes is a technique that is sometimes used in slippery conditions to allow the wheels to unlock so that the vehicle stays somewhat straight during a stop. In a car with ABS the wheels should never lock in the first place, so pumping the brakes will just make you take longer to stop.

In an emergency stop in a car with ABS, you should apply the brake pedal firmly and hold it while the ABS does all the work. You will feel a pulsing in the pedal that may be quite violent, but this is normal so don't let off the brake.

- **Do anti-lock brakes really work?**

Anti-lock brakes really do help you stop better. They prevent wheels from locking up and provide the shortest stopping distance on slippery surfaces. But do they really prevent accidents? This is the true measure of the effectiveness of ABS systems.

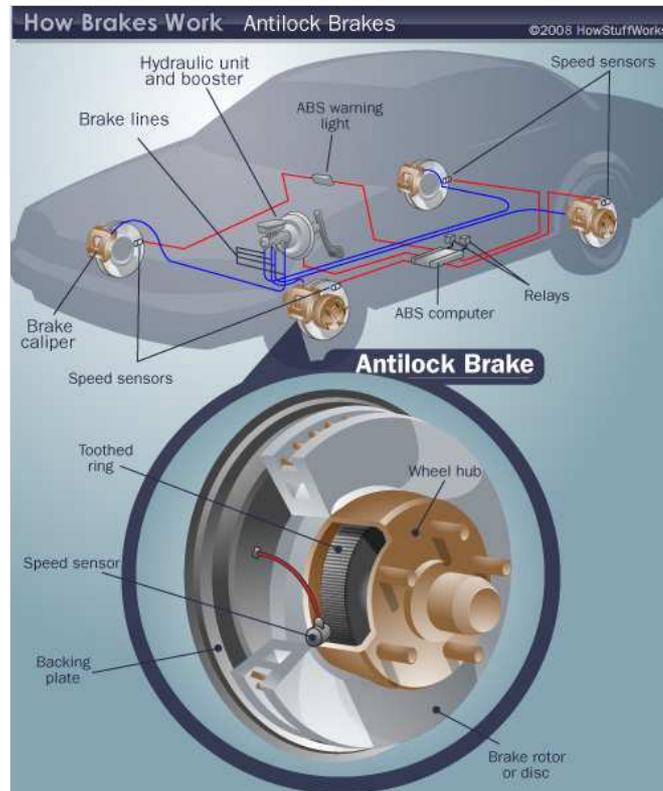
The [Insurance Institute for Highway Safety](#) (IIHS) has conducted several studies trying to determine if cars equipped with ABS are involved in more or fewer fatal accidents. It turns out that in a 1996 study, vehicles equipped with ABS were overall no less likely to be involved in fatal accidents than vehicles without. The study actually stated that although cars with ABS were less likely to be involved in accidents fatal to the occupants of other cars, they are more likely to be involved in accidents fatal to the occupants of the ABS car, especially single-vehicle accidents.

There is much speculation about the reason for this. Some people think that drivers of ABS-equipped cars use the ABS incorrectly, either by pumping the brakes or by releasing the brakes when they feel the system pulsing. Some people think that since ABS allows you to steer during a panic stop, more people run off the road and crash.

Some more recent information may indicate that the accident rate for ABS cars is improving, but there is still no evidence to show that ABS improves overall safety.

Anti-Lock Brake Diagram

Now let's put the parts together to see how anti-lock brakes work as a whole. This diagram provides both a closeup view and an example of where the brakes are located in your vehicle.



Anti-lock brake components

For more information on anti-lock brakes and related topics, check out the links on the next page.

Lots More Information

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- [How Drum Brakes Work](#)
- [How Disc Brakes Work](#)
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